Applying Six Sigma Methodology to Energy-Saving Projects

Case Study

Summary

The Dow Chemical Company is a leading science and technology company that provides innovative chemical, plastic, and agricultural products and services to many essential consumer markets. With annual sales of $27 billion, Dow serves customers in more than 170 countries and a wide range of markets that are vital to human progress, including food, transportation, health and medicine, personal and home care, and building and construction, among others. Committed to the principles of Sustainable Development, Dow and its approximately 50,000 employees seek to balance economic, environmental, and social responsibilities. In 1998 Dow chose to implement Six Sigma methodology to accelerate the company's rate of improvement in quality and productivity. A trial of Six Sigma in two of Dow's global businesses convinced management that the value proposition was well worth the effort, and in September 1999 the company launched a corporate-wide program to incorporate the Six Sigma methodology into all of its businesses and functions.

The company's 1999 annual report stated that by the end of 2003, Dow expected its Six Sigma implementation to deliver revenue growth, cost reductions, and asset utilization totaling $1.5 billion in earnings before interest and taxes (EBIT). At the close of 2002, Dow achieved its $1.5 billion cumulative financial goal—a full year ahead of schedule.

This case study presents four examples of Six Sigma implementation for projects at Dow facilities in Texas and Louisiana:

- Steam Trap Improvement
- Polycarbonate Unit Energy Reduction
- Styrene Unit Energy Envelope
- Angus Site Energy Reduction

What Is Six Sigma Methodology?

Six Sigma is a methodology, tool set, and mindset that accelerates the implementation of business strategies. As defined by Dow, Six Sigma is:

A quality discipline that focuses on product and service excellence to create a culture that demands perfection—on target, every time!

The Greek letter "σ," or sigma, is a mathematical term that represents a measure of standard deviation, or variability within a given population around the mean. Mathematically, six sigma refers to the population that falls within plus or minus six standard deviations.

The term "six sigma" is used as a measurement standard in defining a normal curve of statistical data. Motorola engineers expanded on the term in the 1980s when they decided that the traditional quality levels (measuring defects in thousands of opportunities) were inadequate. Instead, they wanted to measure the defects per *million* opportunities. By using statistical analysis to minimize variation, Six Sigma enables data-based process improvements.

As shown below, operating at Six Sigma quality levels produces 99.9997% accuracy, with only 3.4 defects per million opportunities.

Range of Six Sigma Quality

σ	% Accuracy	Defects per Million Opportunities
1	30.85	691,500
2	69.15	308,500
3	93.32	66,800
4	99.38	6,210
5	99.977	233
6	99.9997	3.4
7	99.999998	0.020

Six Sigma is designed to dramatically upgrade a company's performance, improving quality and productivity. Using existing products, processes, and service standards, Dow employs Six Sigma MAIC methodology to upgrade performance. **MAIC** is defined as follows:

Measure – Gather the right data to accurately assess a problem.

Analyze – Use statistical tools to correctly identify the root causes of a problem.

Improve – Correct the problem (not the symptom).

Control – Put a plan in place to make sure problems stay fixed and sustain the gains.

Key Roles and Responsibilities

When implementing Six Sigma, Dow assigns each project a unique organizational structure starting with top-level support from Dow's CEO. The key roles in all Six Sigma efforts at Dow are as follows:

- **Sponsor** – Business executive leading the organization.
- **Champion** – Responsible for Six Sigma strategy, deployment, and vision.
- **Process Owner** – Owner of the process, product, or service being improved—responsible for long-term sustainable gains.
- **Master Black Belts** – Coach black belts—expert in all statistical tools.
- **Black Belts** – Work on 3 to 5 $250,000-per-year projects; create $1 million per year in value.
- **Green Belts** – Work with black belt on projects.

Project Implementation

This case study highlights the following four Six Sigma projects recently implemented by Dow.

Steam Trap Implementation Project
Texas City, TX

Optimize the steam delivery in energy systems by reducing steam loss through steam traps.

Polycarbonate Unit Energy Reduction Project
Freeport, TX

Ascertain why the Freeport PC plant has consumed twice the energy per pound of product as a similar Dow PC plant in Germany.

Styrene Unit Energy Envelope Project
Freeport, TX

Identify opportunities to optimize plant energy heat integration, improve efficiency, and reduce $CO/CO_2/NO_x$ emissions.

Angus Site Energy Reduction Project
Sterlington, LA

Optimize operation/maintenance of the primary boilers and the steam-reducing station without exceeding boiler air permits.

These projects were identified for Six Sigma implementation to improve product quality and energy performance. Outcomes of the MAIC process are outlined on the following page.

Project	Phase	Results
Steam Trap Implementation Project	**Measure**	• 75 failed traps identified. • 45 visible steam leaks identified.
	Analyze	• Prioritize steam traps and pressure applications based on annualized steam loss. • Leverage information on inverted bucket traps from other Six Sigma projects. • Validate that 600-pound steam is superheated.
	Improve	• After repairs are complete, 87.3% of the steam lost through failed traps and leaks will be recovered.
	Control	• Create a predictive preventative program for steam trap maintenance.

Project	Phase	Results
Polycarbonate Unit Energy Reduction Project	**Measure**	• 17% increase in energy from 2000 to 2001. • 13% increase from 1999 to 2001 in energy use compared to Best-In-Class.
	Analyze	• Validate root causes (steam, nitrogen, air, and electricity losses). • Establish monthly measurement plan for steam, nitrogen, air, and electricity losses.
	Improve	• Reduced energy use by 10%. • Repaired leaks. • Implemented a mind-set change to reduce electrical use within buildings.
	Control	• Maintain use of devolatilization system. • Document identified leaks. • Promote the “waste reduction always pays” mindset.

Project	Phase	Results
Styrene Unit Energy Envelope Project	**Measure**	• Average boiler efficiency 69%. • 143,000 pounds per hour of wasted condensate.
	Analyze	• Data analysis to quantify major effects. • Pinch study to look for heat-integration opportunities. • Engineering tools to analyze. • Brainstorming.
	Improve	• Improved distillation tower efficiency will reduce energy use by 17 MMBtu per hour. • Process furnaces efficiency improvement will reduce conversion energy by 20 MMBtu per hour. • Boiler efficiency improvement will reduce energy use by 25 MMBtu per hour. • Heat integration will reduce energy use by 18 MMBtu per hour.
	Control	• In progress.

Project	Phase	Results
Angus Site Energy Reduction Project	**Measure**	• Boilers operating outside of efficiency target 64% of the time. • Steam temperature delivered to downstream users via pressure reducing valve (PRV) was higher than necessary.
	Analyze	• Establish high alarm for “percent excess oxygen” based on efficiency target. • Minimize PRV losses. • Incorporate steam desuperheater downstream of PRV to control temperature.
	Improve	• Boilers operating outside of efficiency target 22% of the time—66% improvement. • Consulted boiler manufacturer regarding operating boilers at lower pressures to reduce PRV losses. • Installed steam desuperheating nozzle.
	Control	• Implemented efficiency-based excess oxygen operating limits. • Instituted alarms for efficiency standards. • Developed operating discipline to run boilers at lower pressure. • Developed operating procedures to control PRV downstream steam temperature with desuperheating nozzle.

Results

All four projects realized savings as a result of the Six Sigma process implementation. Key cost savings identified by the four projects are as follows:

Steam Trap Improvement Project:	$220,000 savings to date in the first year.
Polycarbonate Unit Energy Reduction Project:	$240,000 savings to date. Savings expected to reach $500,000 per year.
Styrene Unit Energy Envelope Project:	80 MMBtu per hour energy reduction.
Angus Site Energy Reduction Project:	$474,000 savings to date. Savings expected to reach $600,000 per year.

The Office of Energy Efficiency and Renewable Energy of the U.S. Department of Energy conducts technology showcases to encourage industry adoption of energy efficiency technologies and practices. Replication throughout industry can boost productivity and help achieve National goals for energy, the economy, and the environment.

For more information, please visit our Web site: www.eere.energy.gov

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